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TNK062 Traffic modeling
2007-11-23

Computer exercise with Capcal

Introduction

This computer exercise is an introduction to the calculation program Capcal 3. Capcal (CAPacity CALculation) is a computer program for calculating effects of intersections and roundabouts. In this exercise you will practice calculations of non-signal intersection, signal intersections, and roundabouts. For some of the tasks will blueprints from VU-94 (Road design 94) be used, these blueprints is available in the appendix (but not in digital form). Except the guidance in this document there is also a program manual at c:\program\capcal3 (unfortunately only in Swedish) and a help function which can be accessed via the F1-button on the keyboard.

The aim with this exercise is to increase your knowledge on different intersections types' effects intersection performance. The aim is also to increase the understanding of how different traffic signal strategies work and which effect they have on an intersection. The examination in the traffic signal part in the course TNK062 Traffic modeling will include a small project with Capcal and the aim of this exercise is therefore also to give basic knowledge for running Capcal.

In this document will menu and tab choices be written in **bold style,** for example: perform calculation (**Calculation, Intersection**).

Input and calculation

Start Capcal from the shortcut on the start menu and program\Capcal\. Input data to Capcal is prepared in the tabs *Geometry/overview*, *Volumes*, and *Signal*. There is also a tab for Report and Printout, see Figure 1.

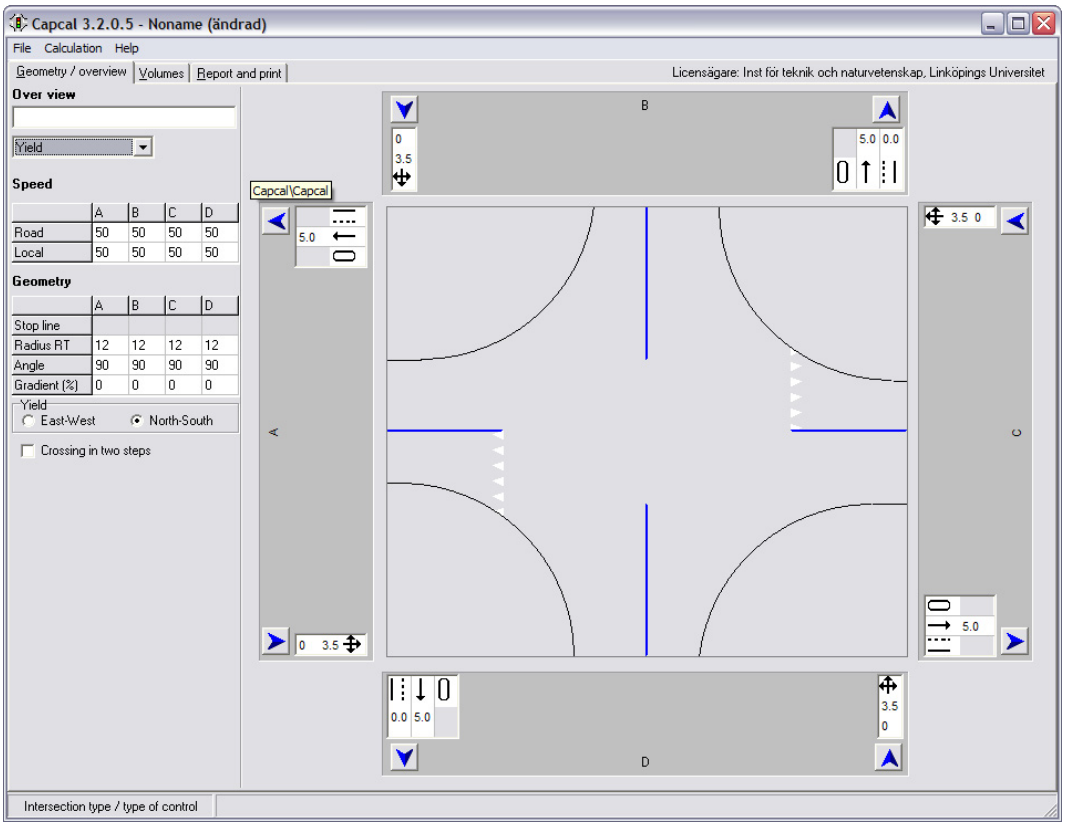


Figure 1 Screen picture from CAPCAL

The data that should feed into Capcal varies depending on intersection type and which calculation that should be performed. Non-signal intersections for example only demand data under the *Geometry* and *Volumes* tab while signal intersections also demand input data under the *Signal* tab. It is for each intersection type only possible to edit the data needed for the calculation of the specific intersection type.

Calculation settings

Capcal can be used to conduct different kinds of calculations. The type of calculation should be performed can be edited from the Calculations menu by marking or unmarking *Cost Analysis* and *ADT-Calculation*. We will not conduct any cost or ADT-calculations within this exercise, thus unmark the two alternatives (**Calculations, Cost Analysis** and **Calculations, ADT-Calculation**)

Geometry input

The appearance of the tab Geometry/overview varies depending on which intersection type that is chosen in the drop-down list up to the left. The tab has one appearance for stop, one for yield, one for signal, and one for roundabouts. Figure 2 shows the different data that can be edited for each approach. The allowed turnings are edited by clicking with the right mouse button on the picture that shows the allowed turnings. The gradient is the vertical incline of the current approach.

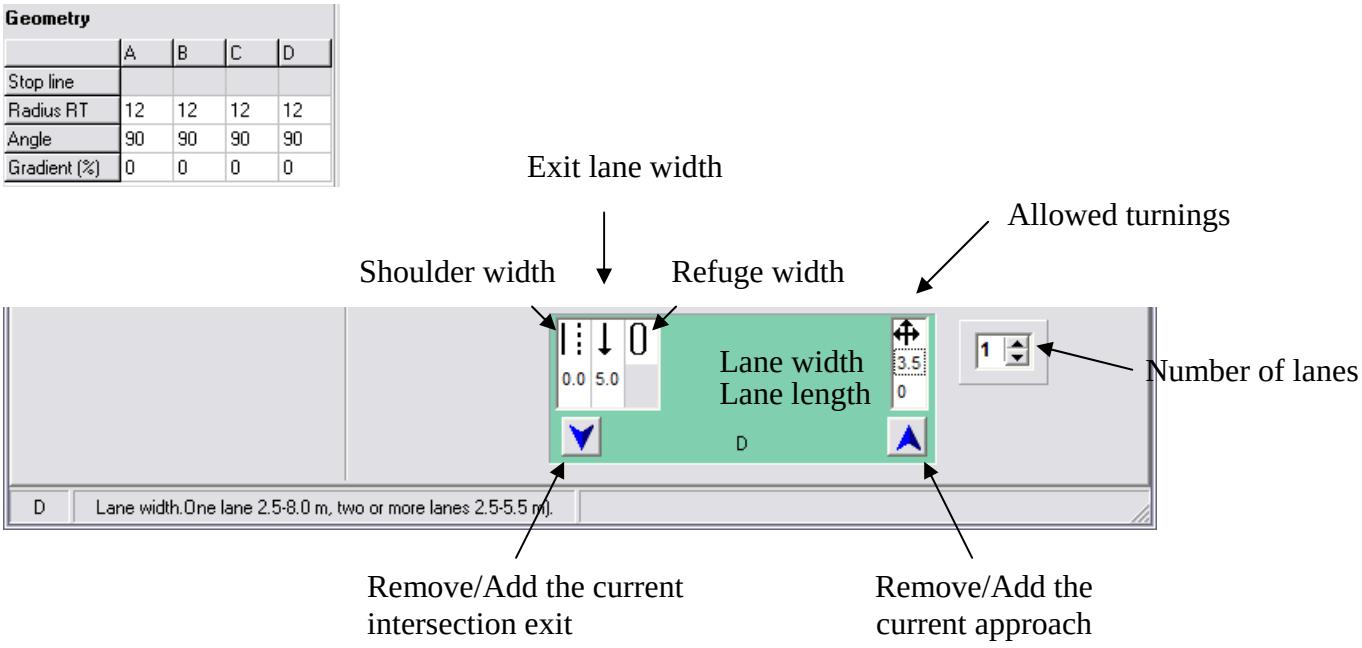


Figure 2 Geometry input to CAPCAL

Some of the input data is illustrated in Figure 3.

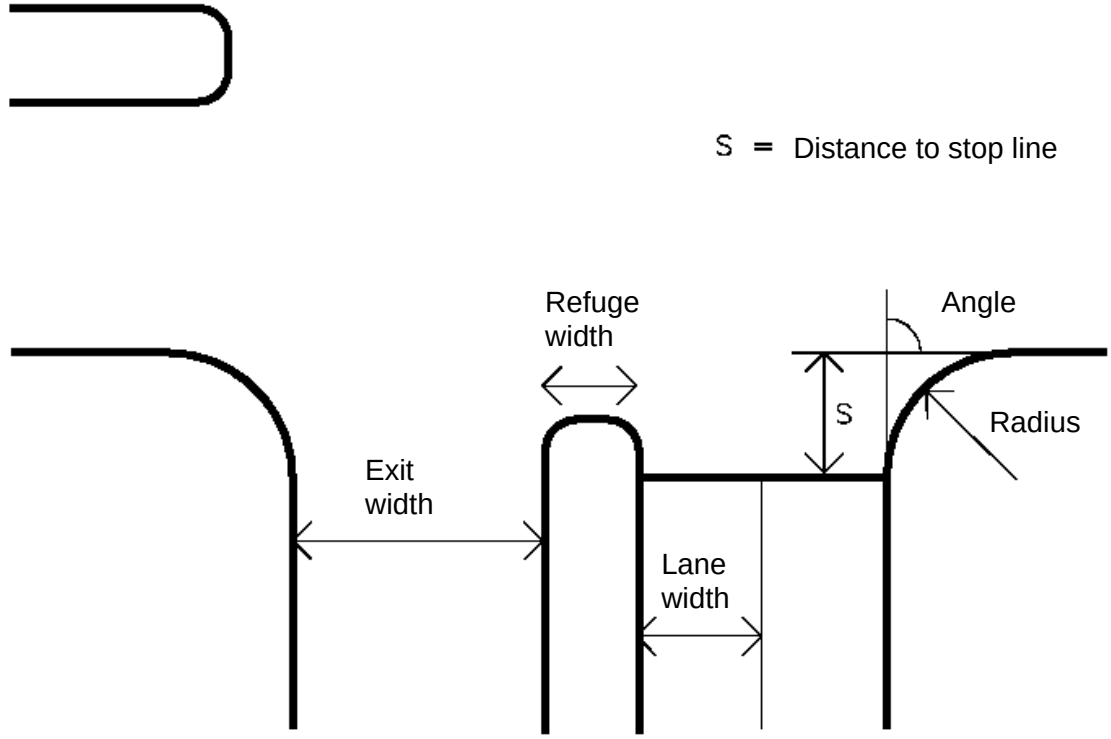


Figure 3 Illustration of some of the geometric input data (Source: Capcal User manual)

Figure 4 and Figure 5 illustrate some additional geometric input data for roundabouts.

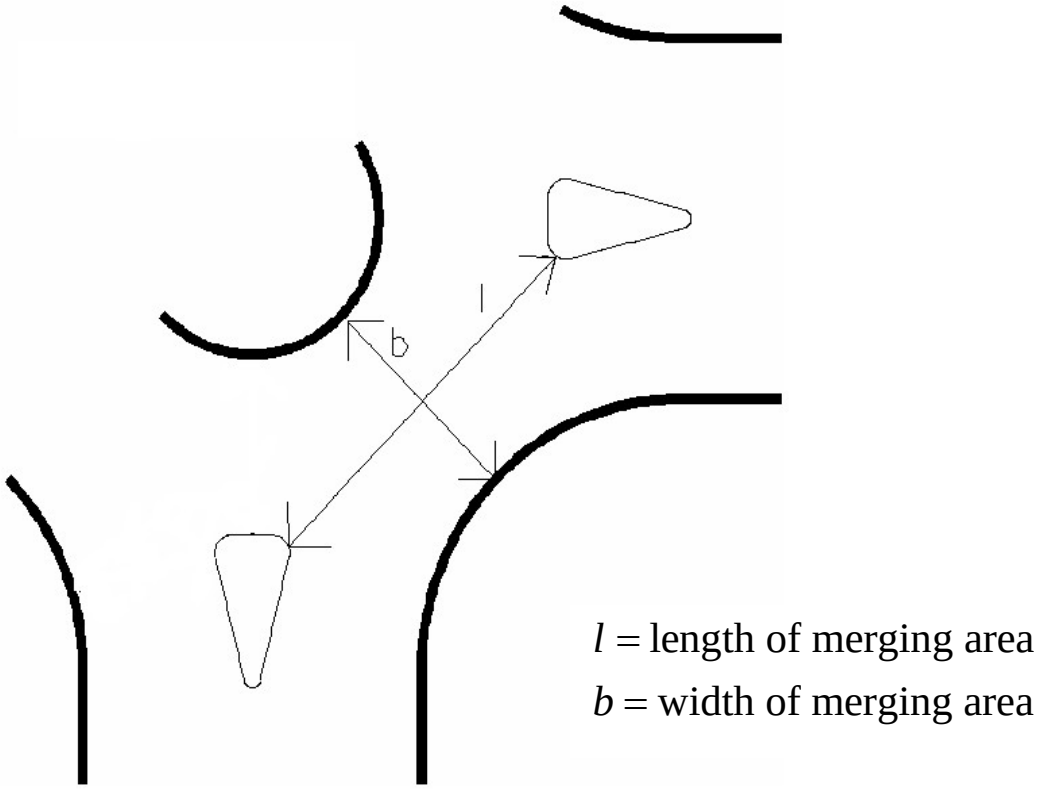


Figure 4 Illustration of some of the geometric input data (Source: Capcal User manual)

The width of the merging area is no longer used in Capcal. Instead the number of circulating lanes should be specified, i.e. number of lanes in the roundabout and not the number of lanes in the approaches. The length and the number of lanes in the roundabout are specified under the Header Roundabout, see screen-shot on next page.

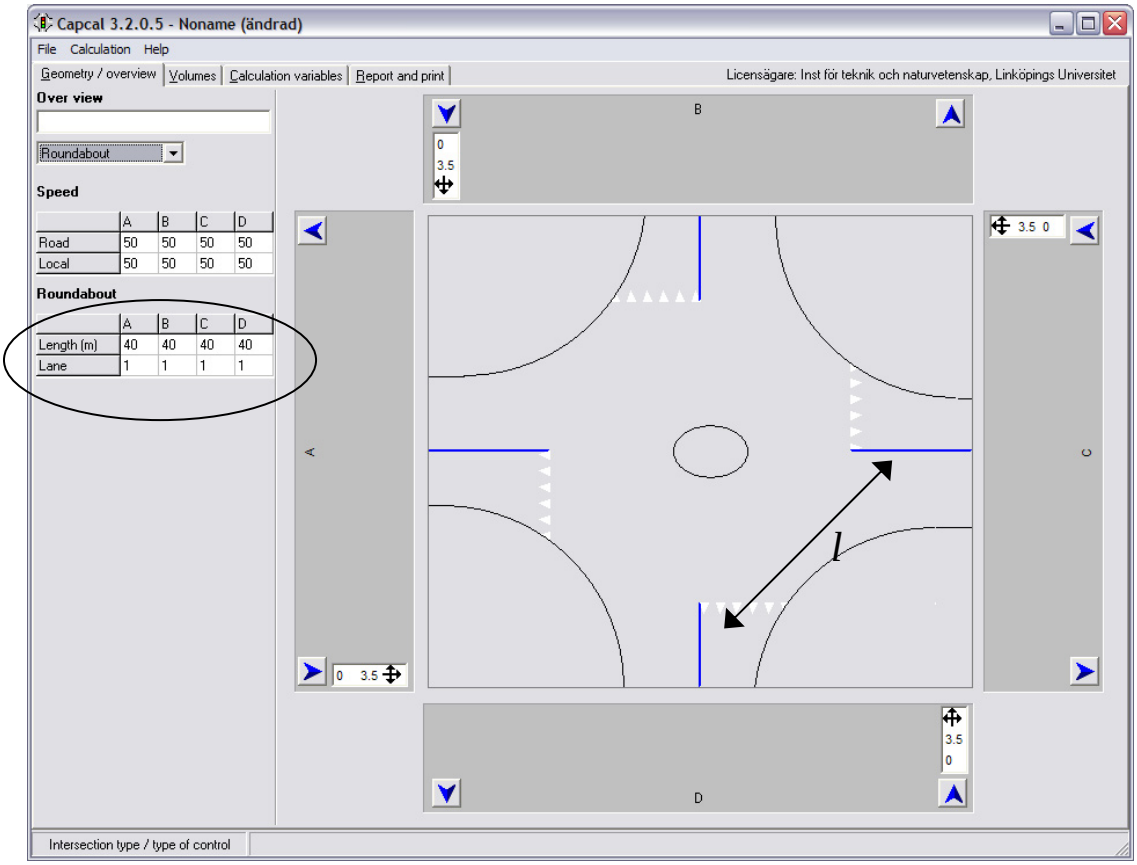
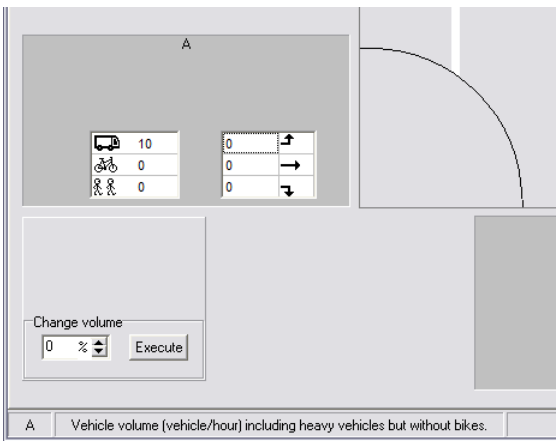


Figure 5 Illustration of geometric input data for roundabouts in Capcal

Traffic input

Each approach and turn relation has to be assigned a traffic volume (vehicles/h). The proportion of trucks in percent is edited in the box besides the truck symbol. The bicycle edit box refer to the number of bicycles (cycles/h) driving among the vehicles in the lane, thus not bicycles on separate tracks. The pedestrian edit box refer to pedestrians and bicycles that cross the approach using an zebra-crossing, but only if the zebra crossing lies in connection with the intersection.



Intersection type A

Create a new intersection (**File**, **New**). Choose *yield* regulation and set the speed limit both for the road and local to 50 km/h. Use geometric input data from blueprint A-3 gm (appendix 1), make reasonable assumptions for data that is missing.

Change to the **volumes** tab and add traffic volumes according to Table 1.

A			B			C			D		
left	straight	right	left	straight	right	left	straight	right	left	Straight	right
	340	120				90	400		45		70

Table 1 Vehicle volumes for exercises concerning intersection types A, B, and C. Heavy vehicle share 10%, and pedestrian and bicycle flow equal to 0.

Save the intersection (**File**, **Save**). Conduct calculations (**Calculation**, **Intersection**) and view the results under the **Report and Print** tab[1]. It is possible to choose which input and output data that should be shown.

Change regulation to stop instead of yield. Save the intersection with a new file name and redo the calculation. Compare the results, are there any differences? If so what is the reason?

_____

_____

An alternative to start to prepare a Capcal intersection from scratch is to use one of the standard intersections available in the Capcal program directory under typkorsning. Choose a standard intersection similar to A-3gm and feed the model with traffic volumes. Calculate and compare the results with the earlier results. Is there any differences? (Why/why not?)

_____

_____

Note: The results from Capcal depend on several variables. Some of them have a large impact on the result, for example the number of lanes while other has little impact, for example the lane width. Please experiment in order to find out which impact different variables have on the result. Test for example to increase the number of lanes and the lane width at some other approach.

The two most used measures of quality-of-service are delay and degree of saturation. Increase the traffic flow successively and study how delay and degree of saturation changes, do the delay and degree of saturation have a positive or negative correlation?

_____

_____

What happens when the degree of saturation gets close to 1?

_____

_____

[1] The results are also saved in the file capout.xls which is available in c:\program\capcal3\.

Quality-of-service measurements

The document VU-94 (http://www3.vv.se/vu94s2/) include a quality-of-service measurement based on the degree of saturation, see Table 2. The measure is defined per lane and refers to the lane with the highest degree of saturation.

Intersection type	High standard	Moderate standard	Low standard
ABCD	<0,5	0,5-0,7	>0,7
E	0,5-0,7	0,3-0,5; 0,7-0,8	<0,3; >0,8

Table 2 Quality-of-service measure based on degree of saturation according to VU-94.

Grade the level of service for the A-3gm intersection – and henceforth – according to Table 2. How good is the quality-of-service?_____

_____

Other quality-of-service measures are delay and queue lengths. Delay is probably the measure that most road users observe. Delay is also the measure that is easiest to express in monetary terms. Queue lengths are important for dimension of extra lanes in an intersection (vehicle store possibilities) and for controlling that the queues do not block intersections upstream.

Intersection type B

What is characteristic for intersection type B?_____

_____

Create a new intersection (**File**, **New**). Use blueprint B-3gm (appendix 1b) feed the model with the necessary geometric data. Choose *yield* regulation. Add traffic volumes according to Table 1.

Save the intersection, conduct the calculation, and view the results. Are there any differences compared to intersection type A? Why/why not?_____

_____

_____

How high is the level of service for this intersection?_____

_____

Intersection type C

What is characteristic for intersection type C?_____

_____

Create a new intersection. Use blueprint C-1g (appendix 2) and feed the model with the necessary geometric data. Choose *yield* regulation and add traffic volumes according to Table 1.

Save the intersection, conduct the calculation, and view the results. Are there any differences compared to intersection type A? Why/why not?_____

_____

_____

How high is the level of service for this intersection?_____

_____

Intersection type D

What is characteristic for intersection type D?_____

Choose any of the intersections model calculated above. Change regulation to *roundabout*. Redo the calculations and compare the results with the chosen intersection. What are the differences? _____

_____

_____

Create a new intersection. Use blueprint D-4g (appendix 3) and feed the model with the necessary geometric data. The B-street have speed limit 50 km/h while the other streets have 70 km/h. Use traffic volumes from Table 3.

A			B			C			D		
left	straight	right	left	straight	right	left	straight	right	left	Straight	right
230	790	160	30	140	200	330	530	40	230	190	490

Table 3 Traffic volumes for a roundabout for the afternoon peek. Heavy vehicle share equal to 10 %, and a pedestrian flow of 230 pedestrians/h crossing the B-street.

How high is the level of service for this intersection?_____

How long is the total interaction delay?_____

Change the geometry of the intersection to only one incoming lane per approach. Redo the calculations and compare the results. What differences can be observed? _____

_____

Intersection type E

Terms

Open the standard intersection *Eovra4* (available from the Capcal program directory under typkorsning). View the signal phases and signal groups from the **Signal** tab.

How many signal groups are there? _____

How many phases are there?_____

It is possible to edit the phases as one desire but with the restriction that primary conflicts is not allowed. There are also some other restrictions. Test to allow straight forward traffic in phase 2 by clicking on the arrow. Conduct a calculation, what happens? (Notice the information in the information field at the bottom of the Capcal window)_____

_____

_____

Thus, it is not possible to conduct a calculation when the phase configuration is conflicts with the rules for signal groups, which is the signal group rules?_____

_____

_____

Information about which conditions that is not fulfilled is given at the information field at the bottom of the program window.

Edit the phase pictures to the original set up. Click with right mouse bottom on phase 2 and click on **Edit** in the pop-list that appears. It is now possible to edit the phase freely. It is now possible to allow right turnings from approach D, do so and then close the dialog box. The phase now becomes grey, which means that there exists a primary conflict. However if it in this case is possible (enough space etc) to turn left from C and right from D at the same time there is no conflict. Perform a calculation, what happens? _____

_____

Below follows an overview of some important traffic signal terms in Capcal

Signal control	Capcal calculates a *fixed time* signal, i.e. the signal is not affected by the traffic in real-time. The signal control should be changed to *Signal group control* when modeling modern adaptive traffic signal. Capcal then performs a correction of the results so that they better correspond to a modern traffic signal.
Cycle time	The cycle time can be set by the user (30-200s) or be set to be calculated by the program (40-120s). If Capcal is set to calculate the best cycle time, all values between 40 and 120 s with intervals of 5 s is tested.

Safety time	The safety time cannot be handled at signal group level. The safe time must instead be set to the safe time that is dimensional for the phase.
Min green	The min green time should be set to 4 or 6 seconds for motor vehicles (normally 4 seconds at roads with speed limit 50 km/h and 6 seconds at roads with speed limit 70 km/h). Min green time for pedestrians must be set so that they are able to cross the road during the min green time.
Max green	The max green time should normally not be set. A value of 0 means that the max time is unrestricted.
Start offset, End offset	Start and end offset time can be used when more than one signal group have right of way in a phase in order to model that the signal groups have different start and/or end times.

It is normally only the safe and min green time that needs to set. The calculations is not that exact that offset times has any large impact. Capcal is not recommended for calculations of coordinated traffic signals since it cannot handle the effects of the coordination. Capcal will give a higher delay than reasonable. For coordinated systems one should use programs like TRANSYT.

Tasks

Do calculations for example 1-3 from TV131 (see appendix 4-7). Please observe that there is both morning and afternoon traffic volumes available for example 3. Use the following safe times: 3 s (example 1), 4 s (example 2), and 5 s (example 3). Do not take the short lanes into considerations. The phase configurations is explained below and in illustrated in appendix 7.

Example 1: Mixed phase (2-phase).

Example 2: Phase 1 all turnings from west and east. Phase 2 all turnings from east. Phase 3 all turnings from north and south.

Example 3: Phase 1 right and straight turnings from west and east. Phase 2 all turnings from north and south. Phase 3 left turnings from west and east. Phase 4 all turnings from west.

Calculate the different intersections. Do the intersections work sati factionary? _____

_____

_____

If the degree of saturation exceeds 0.7 for any of the intersections try to modify the intersections or the signal timing so that degree of saturation gets below 0.7. Which methods did you test and which of them worked? _____

_____

_____

Redo the calculations for example 1 and 2 but now with the length restrictions for the short lanes. Do the results change noticeable? _____

_____

How to choose intersection type

The Swedish road administration has developed a rough calculation method that can be used to give indications on which intersection type that is suitable, see Figure 6. Use the method to check which intersection type that is suitable for the 7 different intersections in Table 4. ´Choose Intersection type (god (good) = smaller intersection type, mindre god (moderate) = consider larger intersection type, black marked area = larger intersection type).

A			B			C			D		
Left	Straight on	Right	Left	Straight on	Right	Left	Straight on	Right	Left	Straight on	Right
90	340	120	70	65	40	90	400	95	45	30	70
90	340	120	150	65	40	90	400	95	150	30	70
90	340	120	40	65	150	90	400	95	70	30	150
90	230	120	75	65	40	90	220	95	65	30	70
90	90	60	75	65	40	90	150	95	65	30	70
130	90	60	130	65	40	90	150	95	65	30	70
230	550	120	70	65	40	115	650	120	45	30	70

Table 4 Traffic volumes for 7 different intersections.

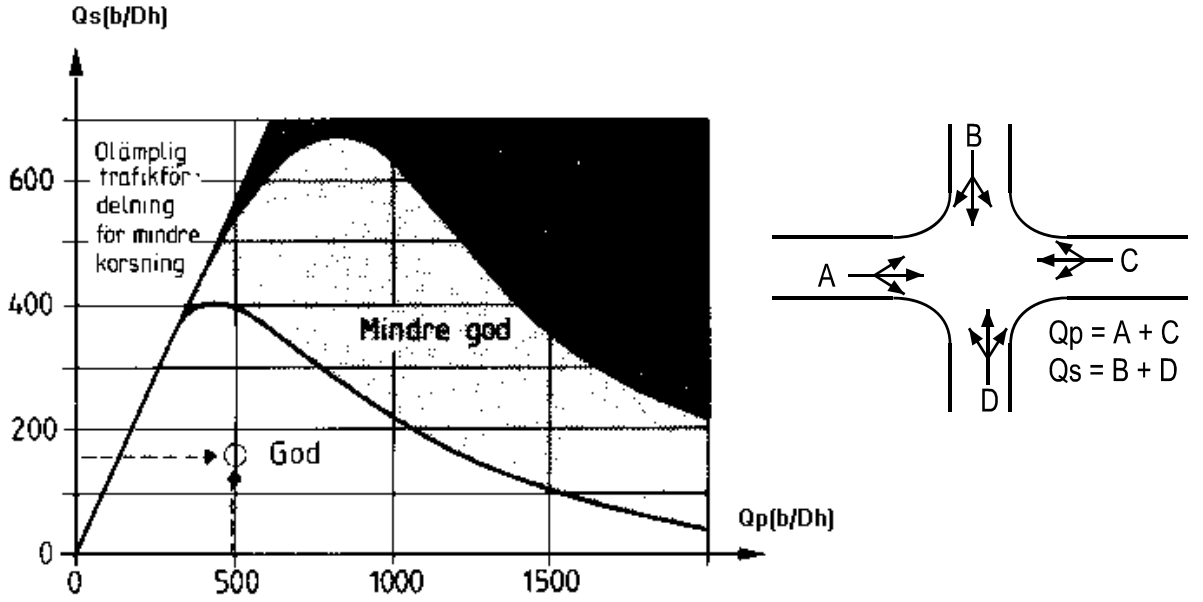


Figure 6 Rough calculation method for control of degree of saturation during the dimension hour for an urban intersection. (figur 7.5.2-2, VR50 för fyrvägskorsning ur VU-94)

Calculate the degree of saturation with Capcal for one or more of the intersections. Grade the quality-of-service and compare it to the VU94 method, is the answer the same?_____

Calculations of Dalbyvägen in Lund

Appendix 8 shows an overview of the south-east parts of the Swedish city Lund. There are four main intersections in the overview picture (Dalbyvägen/Tornavägen, Dalbyvägen/E22, Dalbyvägen/Porfyrvägen and Albyvägen/Sandbyvägen). Signal phase schemes are available in appendix 9-12, i.e. signal controllers 46, 912, 15 and 941.

Traffic volumes are found in Table 5 to Table 7 (flows for Dalbyvägen/E22 is missing).

		Flow (vehicles/h)			
		Morning		Afternoon	
Approach	**Turning**	**Today**	**Forecast**	**Today**	**Forecast**
W	Left	34	49	52	73
	Straight on	303	423	656	918
	Right	8	11	28	39
	Total	345	483	736	1030
	Pedestrians	20	30	13	15
N	Left	205	281	317	444
	Straight on	110	162	99	139
	Right	18	22	32	45
	Total	333	465	448	628
	Pedestrians	143	189	196	223
E	Left	258	372	201	281
	Straight on	513	748	460	644
	Right	393	578	175	245
	Total	1164	1698	836	1170
	Pedestrians	43	57	45	60
S	Left	9	13	13	18
	Straight on	118	164	99	139
	Right	181	255	318	445
	Total	308	432	430	602
	Pedestrians	101	129	73	100
Total		2150	3078	2450	3430

Table 5 Traffic volumes for Tornavägen/Dalbyvägen (peek hour). Heavy vehicle share 3 %.

		Flow (vehicles/h)			
		Morning		Afternoon	
Approach	**Turning**	**Today**	**Forecast**	**Today**	**Forecast**
W	Left	167	225	102	147
	Straight on	446	599	1054	1520
	Right	571	767	317	458
	Total	1184	1591	1473	2125
N	Left	4	6	3	4
	Straight on	29	39	24	34
	Right	138	185	157	227
	Total	171	230	184	265
E	Left	127	171	58	83
	Straight on	1136	1527	640	923
	Right	2	3	7	10
	Total	1266	1701	704	1016
S	Left	224	301	451	650
	Straight on	28	38	24	34
	Right	31	42	143	206
	Total	283	381	617	890
Total		2904	3903	2978	4296

Table 6 Traffic volumes for Porfyrvägen/Dalbyvägen (peek hour). Heavy vehicle share 3 %.

		Flow (vehicles/h)			
		Morning		Afternoon	
Approach	**Turning**	**Today**	**Forecast**	**Today**	**Forecast**
W	Left	180	647	467	252
	Straight on	276	1001	733	386
	Right	50	22	18	70
	Total	506	1670	1218	708
N	Left	26	113	82	36
	Straight on	113	63	50	158
	Right	527	378	275	738
	Total	666	554	407	932
E	Left	46	21	18	69
	Straight on	769	372	282	1035
	Right	73	20	14	102
	Total	888	413	314	1206
S	Left	23	101	73	32
	Straight on	39	136	97	55
	Right	17	113	81	24
	Total	79	350	251	111
Total		2139	2987	2190	2957

Table 7 Traffic volumes for Albyvägen/Sandbyvägen (peek hour). Heavy vehicle share 3 %.